National High Blood Pressure Education Program

Update on the Task Force Report (1987) on High Blood Pressure in Children and Adolescents:

A Working Group Report From the National High Blood Pressure Education Program

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Foreword

Since the publication of the Report of the Second Task Force on Blood Pressure Control in Children—1987 (*Pediatrics*. 1987;79:1-25), new information has become available to assist pediatricians in identifying, preventing, and treating high blood pressure in children. Although hypertension generally was treated as an indication of a secondary medical problem in the past, it is now known that elevated blood pressure in many young persons may be the first sign of future adult essential hypertension.

This report was produced by a working group appointed by the National High Blood Pressure Education Program (NHBPEP) under the capable leadership of Dr. Bonita Falkner. The report drew upon the combined knowledge and experience of pediatricians, pediatric cardiologists, clinicians, epidemiologists, and public health specialists.

This report updates the 1987 report and includes the following new information.

- New data, such as results from the 1988-91 National Health and Nutrition Examination Survey, have been included to develop revised normative blood pressure tables, which now include height percentiles, age, and gender.
- The normative blood pressure tables use the fifth Korotkoff sound for the definition of diastolic blood pressure for all age groups except infants younger than 1 year of age.
- New charts have been developed to guide practicing clinicians in selecting antihypertensive drug therapy. These include newer classes of drugs not available at the time of the last report.
- A public health statement encourages health professionals to promote healthy lifestyles in all children and adolescents.
- Easy-to-use physician education charts provide a quick reference tool for clinicians.

Dr. Falkner and the members of the working group are to be congratulated for developing this important document. Pediatric care must be a priority if our efforts to solve important public health problems through prevention and treatment of hypertension are to be successful.

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Introduction

The relevance of childhood blood pressure (BP) measurement to pediatric health care and the development of adult essential hypertension has undergone substantial conceptual change during the past 2 decades. The original orientation of physicians with regard to BP in children and adolescents was toward identification and treatment of secondary forms of hypertension, such as renal parenchymal disease and renal artery stenosis. The incorporation of BP measurement into the routine pediatric examination as well as the publication of national norms for BP in children[1-3] not only enabled detection of significant asymptomatic hypertension secondary to a previously undetected disorder but also confirmed that mild elevations in BP during childhood were more common than previously recognized, particularly in adolescents. It is now understood that hypertension detected in some children may be a sign of an underlying disease such as renal parenchymal disease, whereas in other cases the elevated BP may represent the early onset of essential hypertension.

Since publication of the 1977 task force report,[2] new and more extensive epidemiologic data on normal BP distributions and the natural history of BP throughout the pediatric age range have been published. These data, as well as advances in diagnosis of and therapy for hypertension, prompted publication of the *Report of the Second Task Force on Blood Pressure Control in Children—1987*.[3] From the expanded body of knowledge on hypertension in the young, several sources are now available that provide detailed guidelines for clinical evaluation and treatment of children and adolescents with hypertension.[4-6] The purpose of this report is to update practitioners on new data on BP in children and to call attention to modifications that are recommended for the diagnosis, treatment, and prevention of hypertension in children.

Definition of Hypertension

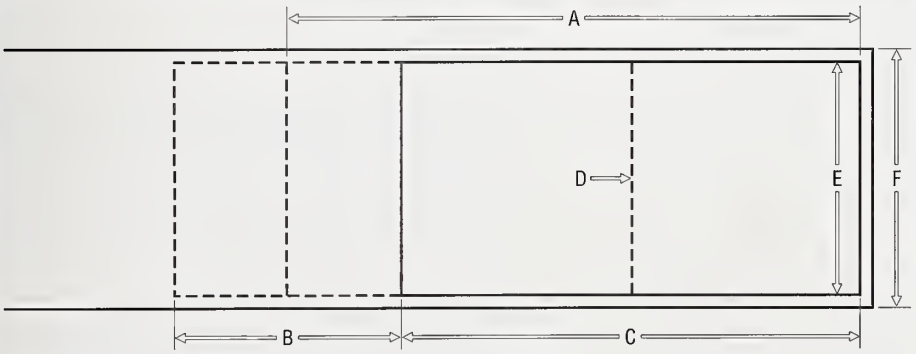
Although clinical hypertension occurs less frequently in children than in adults,[7-9] ample evidence now supports the concept that the roots of essential hypertension extend back to childhood. Familial patterns for BP have been established from early infancy,[10,11] and children with BP in the higher distributional percentiles are more likely to come from families with a history of hypertension.[12,13] Although it is generally agreed that early essential hypertension poses little immediate risk to most children, evidence from preliminary studies of children and adolescents has shown cardiac ventricular and hemodynamic changes consistent with an adverse effect of mild hypertension prior to the third decade of life.[14-19] Of particular importance is the documentation that elevated BP in childhood often correlates with hypertension in early adulthood, thereby supporting the need to track BP in children.[20]

BP varies widely throughout the day in children, as well as in adults, due to normal diurnal fluctuation and changes in physical activity, emotional stress, or other factors. This variability can make the diagnosis of hypertension in children a difficult task. The second National Heart, Lung, and Blood Institute (NHLBI) task force developed definitions based on the distribution of BP in normal children as well as clinical experience and consensus.[3] **Normal** BP is defined as systolic and diastolic BP below the 90th percentile for age and sex. **High-normal** BP is defined as average systolic or diastolic BP greater than or equal to the 90th percentile but less than the 95th percentile. **Hypertension** is defined as average systolic or diastolic BP greater than or equal to the 95th percentile for age and sex measured on at least three separate occasions.

Measurement of Blood Pressure in Children

Methods of BP measurement in children must be standardized.[21,22] BP in children is most conveniently measured with a standard clinical sphygmomanometer, using the stethoscope placed over the brachial artery pulse, proximal and medial to the cubital fossa, and below the bottom edge of the cuff (i.e., about 2 cm above the cubital fossa). Correct measurement of BP in children requires use of a cuff that is appropriate to the size of the child's upper right arm. The right arm is preferred for consistency and comparison to the standard tables. The equipment necessary to measure BP in children age 3 years through adolescence includes three pediatric cuffs of different sizes as well as a standard adult cuff, an oversized cuff, and a thigh cuff for leg BP measurement. The latter two cuffs may be needed for use in obese adolescents. A technique to establish an appropriate cuff size is to choose a cuff having a bladder width that is approximately 40 percent of the arm circumference midway between the olecranon and the acromion. This will usually be a cuff bladder that will cover 80 to 100 percent of the circumference of the arm (see figures 1, 2, 3, and 4). Use of the manufacturer's lines on the cuff facilitates choice of the correct cuff size for a given child. BP should be measured in a controlled environment and after 3 to 5 minutes of rest in the seated position with the cubital fossa supported at heart level. BP should be recorded at least twice on each occasion, and the average of each of the systolic and diastolic

Figure 1: Dimensions of Bladder and Cuff in Relation to Arm Circumference



A: Ideal arm circumference; B: Range of acceptable arm circumferences; C: Bladder length; D: Midline of bladder; E: Bladder width; F: Cuff width

Source: Perloff D et al. Human blood pressure determination by sphygmomanometry. Circulation. 1993;88:2460-2467. Copyright© 1993 American Heart Association. Reproduced with permission.

Figure 2: Determination of Proper Cuff Size, Step 1

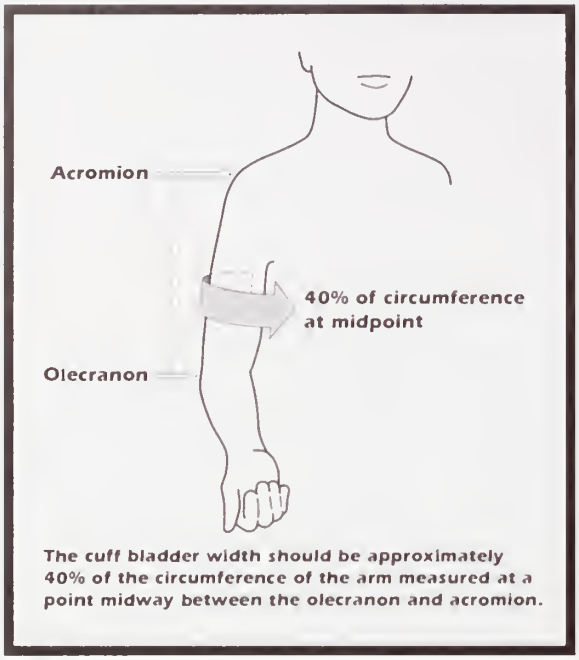
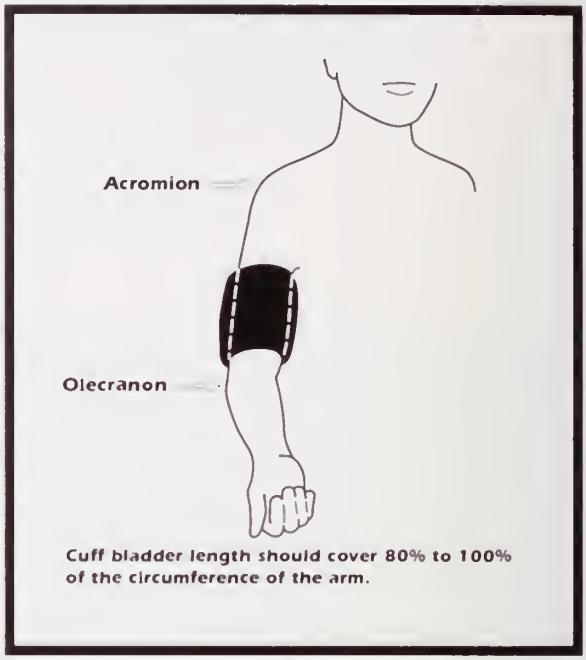


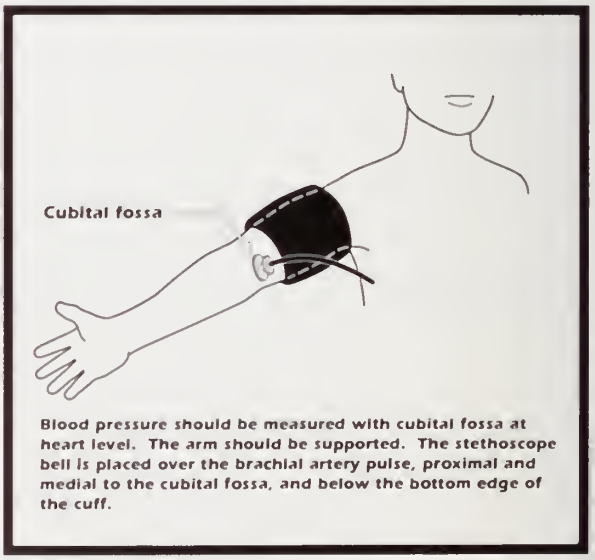
Figure 3: Determination of Proper Cuff Size, Step 2



BP measurements should be used to estimate BP level.

Systolic BP is determined by the onset of the "tapping" Korotkoff sounds. The phase of the Korotkoff sounds that defines diastolic BP has been somewhat controversial. The American Heart Association has established the fifth Korotkoff sound (K5), or the disappearance of Korotkoff sounds, as the definition of diastolic BP. In children, particularly preadolescents, a difference of several mm Hg is frequently present between K4, the muffling of Korotkoff sounds, and K5.[23] In some children, Korotkoff sounds can be heard to 0 mm Hg. When this occurs, it excludes diastolic hypertension. When the second task force report was published, the BP distribution curves were developed from the body of data available, which indicated that K5 was a reliable measure of diastolic BP for children age 13 years and older. The addition of more childhood BP data, with reanalysis of the entire database, now indicates that K5 can be used to define diastolic BP in children as well as adolescents and adults. This change to a K5 definition

Figure 4: Blood Pressure Measurement



of diastolic BP enables a uniform designation of diastolic BP for all ages. The BP tables provided in this report use K5 as the diastolic BP.

In recent years, there has been increasing use of automated devices to measure BP in children. The most commonly used devices utilize oscillometric methodology to measure systolic

and mean arterial BP. Diastolic BP is then calculated from these values. One advantage of these devices is their ease of use. Instances in which use of the automated devices is acceptable include BP measurement in newborns and young infants in whom auscultation is difficult as well as in the intensive care setting where frequent BP measurement is needed. However, the reliability of these instruments in a more standard clinical setting is less clear due to the need for frequent calibration of the instruments and the current lack of established reference standards. Under most circumstances, the recommended method of BP measurement in children is auscultation.

Ambulatory BP monitoring refers to portable BP devices worn by the patient that record BP over a specified period, usually 24 hours. Standards for ambulatory BP recording in children currently are not available, although some data have been published.[24,25] Ambulatory BP monitoring is becoming increasingly popular in the management of hypertension in adults. However, more data are needed before this procedure can be recommended for routine clinical use in children.

Elevated BP must be confirmed on repeated visits before characterizing an individual as having hypertension. This is because BP at the high levels tends to fall on subsequent measurement as the result of (1) an accommodation effect (i.e., reduction of anxiety by the patient from one visit to the next), and (2) regression to the mean, a nonbiological phenomenon that derives, in part, from mathematical considerations. BP level is not static but varies even under standard resting conditions. Therefore, a more precise characterization of an individual's BP level is an average of multiple BP measurements taken over weeks to months. With repeated measurement of BP using measurement techniques standardized for children, only about 1 percent of children and adolescents will be found to have hypertension.

Once a diagnosis of hypertension is confirmed by repeated BP measurements exceeding the 95th percentile, decisions must be made on further evaluation and treatment. Most children and adolescents with BP levels at or just above the 95th percentile for their age and sex are overweight and have a family history of hypertension.[3] For them, a careful history and physical examination are most important. They require few diagnostic tests other than a urinalysis and blood profiles to examine blood urea nitrogen and serum creatinine levels. A cardiovascular risk factor that may be associated with hypertension in children is abnormal lipids. A lipid profile may provide useful information because many overweight children and adolescents with hypertension have elevated triglycerides and low-density lipoprotein cholesterol levels with low high-density lipoprotein cholesterol.

Children and adolescents with both diastolic and systolic BP well above the 95th percentile frequently have an underlying cause of hypertension, usually some form of renal-related disease. In children with hypertension, femoral pulses should be palpated and BP also should be measured in the legs to rule out coarctation of the aorta. Previous reports have reviewed the type and expression of secondary hypertension during childhood and the diagnostic approach recommended to exclude causes of secondary hypertension.[3] Some genetic types of hypertension, such as glucocorticoid remediable aldosteronism, can now be identified by sending a blood sample to centers capable of performing the genetic testing. Although genetic testing for most children is unnecessary at this time, it is appropriate to consult with a physician experienced in the field of childhood hypertension for those children in whom further testing for underlying causes of hypertension is indicated to determine the type and extent of diagnostic testing necessary for a given child.

New Blood Pressure Tables Adjusted for Height

Body size is the most important determinant of BP in childhood and adolescence. The concept that the differential growth rates present in children would require some adjustments in interpretation of the BP percentile for individual children was suggested in the second task force report. That report included tables for the 90th percentile of height and weight with the sex and age BP distribution curves and indicated that tall children with pressures that seem to be elevated may actually be normotensive if their height for a given age is beyond the 90th height percentile.[3] In a recent report that reanalyzed the national childhood BP data, the BP percentiles were refined and based not only on sex and age but also on height to determine age-, sex-, and height-specific systolic and diastolic BP percentiles.[26] This approach provides information that allows for consideration of different levels of growth in evaluating BP and demonstrates that BP standards that are based on sex, age, and height permit a more precise classification of BP according to body size.[26] More importantly, this approach avoids misclassifying children at the extremes of normal growth. For example, very tall children will not be misclassified as hypertensive, and very short children with high normal BP or even hypertension will not be missed. Although BP clearly is also associated with obesity, this association is believed to be a causal one, wherein the obesity contributes to higher BP and to increased risk for cardiovascular disease.

The BP data in this report on children and adolescents have been updated and reanalyzed to include height percentiles. The report now includes the data presented in the second task force report,[3] the data added in the report by Rosner et al.,[26] and newly obtained data from the 1988-91 National Health and Nutrition Examination Survey (NHANES III).[27] These normative tables are based on the first BP measured during screening on 61,206 children, including 31,158 boys and 30,048 girls. Demographic data for the study population are given in appendix 1.

The 90th and 95th percentiles of systolic and diastolic BP (using the fifth Korotkoff phase) for the 5th through 95th percentiles for height by sex and age are given for children in tables 1 and 2, respectively. The difference in the 90th and 95th percentiles for BP for children of the same age and sex but of different height is apparent in these tables.

The BP tables adjusted for height and age in this report, as compared with the tables using only age, alter the BP percentile estimates of boys and girls at all ages and particularly for very young children. In general, BPs in the 90th and 95th percentiles for sex, height, and age are lower for shorter children than BPs in the 90th and 95th percentiles given for children by age alone. Conversely, tall children are allowed higher normal BPs when their height is taken into consideration than when age alone is used.

Table 1

Blood Pressure Levels for the 90th and 95th Percentiles of Blood Pressure for Boys Age 1 to 17 Years by Percentiles of Height

Age	Height Percentiles* → / BP† ↓	Systolic BP (mm Hg) 5%	10%	25%	50%	75%	90%	95%	Diastolic BP (mm Hg) 5%	10%	25%	50%	75%	90%	95%
1	90th	94	95	97	98	100	102	102	50	51	52	53	54	54	55
	95th	98	99	101	102	104	106	106	55	55	56	57	58	59	59
2	90th	98	99	100	102	104	105	106	55	55	56	57	58	59	59
	95th	101	102	104	106	108	109	110	59	59	60	61	62	63	63
3	90th	100	101	103	105	107	108	109	59	59	60	61	62	63	63
	95th	104	105	107	109	111	112	113	63	63	64	65	66	67	67
4	90th	102	103	105	107	109	110	111	62	62	63	64	65	66	66
	95th	106	107	109	111	113	114	115	66	67	67	68	69	70	71
5	90th	104	105	106	108	110	112	112	65	65	66	67	68	69	69
	95th	108	109	110	112	114	115	116	69	70	70	71	72	73	74
6	90th	105	106	108	110	111	113	114	67	68	69	70	70	71	72
	95th	109	110	112	114	115	117	117	72	72	73	74	75	76	76
7	90th	106	107	109	111	113	114	115	69	70	71	72	72	73	74
	95th	110	111	113	115	116	118	119	74	74	75	76	77	78	78
8	90th	107	108	110	112	114	115	116	71	71	72	73	74	75	75
	95th	111	112	114	116	118	119	120	75	76	76	77	78	79	80
9	90th	109	110	112	113	115	117	117	72	73	73	74	75	76	77
	95th	113	114	116	117	119	121	121	76	77	78	79	80	80	81
10	90th	110	112	113	115	117	118	119	73	74	74	75	76	77	78
	95th	114	115	117	119	121	122	123	77	78	79	80	80	81	82
11	90th	112	113	115	117	119	120	121	74	74	75	76	77	78	78
	95th	116	117	119	121	123	124	125	78	79	79	80	81	82	83
12	90th	115	116	117	119	121	123	123	75	75	76	77	78	78	79
	95th	119	120	121	123	125	126	127	79	79	80	81	82	83	83
13	90th	117	118	120	122	124	125	126	75	76	76	77	78	79	80
	95th	121	122	124	126	128	129	130	79	80	81	82	83	83	84
14	90th	120	121	123	125	126	128	128	76	76	77	78	79	80	80
	95th	124	125	127	128	130	132	132	80	81	81	82	83	84	85
15	90th	123	124	125	127	129	131	131	77	77	78	79	80	81	81
	95th	127	128	129	131	133	134	135	81	82	83	83	84	85	86
16	90th	125	126	128	130	132	133	134	79	79	80	81	82	82	83
	95th	129	130	132	134	136	137	138	83	83	84	85	86	87	87
17	90th	128	129	131	133	134	136	136	81	81	82	83	84	85	85
	95th	132	133	135	136	138	140	140	85	85	86	87	88	89	89

*Height percentile determined by standard growth curves.
†Blood pressure percentile determined by a single measurement.

Table 2

Blood Pressure Levels for the 90th and 95th Percentiles of Blood Pressure for Girls Age 1 to 17 Years by Percentiles of Height

Age	Height Percentiles* → / BP† ↓	Systolic BP (mm Hg) 5%	10%	25%	50%	75%	90%	95%	Diastolic BP (mm Hg) 5%	10%	25%	50%	75%	90%	95%
1	90th	97	98	99	100	102	103	104	53	53	53	54	55	56	56
	95th	101	102	103	104	105	107	107	57	57	57	58	59	60	60
2	90th	99	99	100	102	103	104	105	57	57	58	58	59	60	61
	95th	102	103	104	105	107	108	109	61	61	62	62	63	64	65
3	90th	100	100	102	103	104	105	106	61	61	61	62	63	63	64
	95th	104	104	105	107	108	109	110	65	65	65	66	67	67	68
4	90th	101	102	103	104	106	107	108	63	63	64	65	65	66	67
	95th	105	106	107	108	109	111	111	67	67	68	69	69	70	71
5	90th	103	103	104	106	107	108	109	65	66	66	67	68	68	69
	95th	107	107	108	110	111	112	113	69	70	70	71	72	72	73
6	90th	104	105	106	107	109	110	111	67	67	68	69	69	70	71
	95th	108	109	110	111	112	114	114	71	71	72	73	73	74	75
7	90th	106	107	108	109	110	112	112	69	69	69	70	71	72	72
	95th	110	110	112	113	114	115	116	73	73	73	74	75	76	76
8	90th	108	109	110	111	112	113	114	70	70	71	71	72	73	74
	95th	112	112	113	115	116	117	118	74	74	75	75	76	77	78
9	90th	110	110	112	113	114	115	116	71	72	72	73	74	74	75
	95th	114	114	115	117	118	119	120	75	76	76	77	78	78	79
10	90th	112	112	114	115	116	117	118	73	73	73	74	75	76	76
	95th	116	116	117	119	120	121	122	77	77	77	78	79	80	80
11	90th	114	114	116	117	118	119	120	74	74	75	75	76	77	77
	95th	118	118	119	121	122	123	124	78	78	79	79	80	81	81
12	90th	116	116	118	119	120	121	122	75	75	76	76	77	78	78
	95th	120	120	121	123	124	125	126	79	79	80	80	81	82	82
13	90th	118	118	119	121	122	123	124	76	76	77	78	78	79	80
	95th	121	122	123	125	126	127	128	80	80	81	82	82	83	84
14	90th	119	120	121	122	124	125	126	77	77	78	79	79	80	81
	95th	123	124	125	126	128	129	130	81	81	82	83	83	84	85
15	90th	121	121	122	124	125	126	127	78	78	79	79	80	81	82
	95th	124	125	126	128	129	130	131	82	82	83	83	84	85	86
16	90th	122	122	123	125	126	127	128	79	79	79	80	81	82	82
	95th	125	126	127	128	130	131	132	83	83	83	84	85	86	86
17	90th	122	123	124	125	126	128	128	79	79	79	80	81	82	82
	95th	126	126	127	129	130	131	132	83	83	83	84	85	86	86

*Height percentile determined by standard growth curves.
†Blood pressure percentile determined by a single measurement.

To use the tables in a clinical setting, the height percentile is determined from the standard growth charts. The child's measured systolic and diastolic BP is compared with the numbers provided in the table (boys or girls) for age and height percentile. The child is normotensive if BP is below the 90th percentile. If the child's BP (systolic or diastolic) is at or above the 95th percentile, the child may be hypertensive and repeated measurements are indicated. BP measurements between the 90th and 95th percentiles are high-normal and warrant further observation and consideration of other risk factors.

Standards for systolic and diastolic BP for infants younger than 1 year are available in the second task force report.[3] Additional data recently have been published.[28,29] In children younger than 1 year, systolic BP has been used to define hypertension.

Treatment of Hypertension in Children and Adolescents

Nonpharmacologic Therapy

Nonpharmacologic therapy comprises weight reduction, exercise, and dietary intervention. Nonpharmacologic therapy should be introduced not only in the care of patients with hypertension but also in children with high-normal BP (90th to 95th percentile BP distribution) and to complement drug therapy for patients with severe hypertension.

Body size is the major determinant for BP among children. In obese children, both systolic and diastolic BP may decrease in response to weight loss.[30] In addition, weight loss offers other benefits. The adverse effect of obesity on cardiovascular function[31] is compounded in the presence of hypertension, and overweight adolescents are at increased risk for cardiovascular disease as adults.[32] Weight loss also has a positive effect on serum lipid profiles, and, in obese children, weight loss diminishes the effect of dietary salt on BP.[33] The prevention of obesity in childhood would convey significant benefits in reducing risks for cardiovascular disease as well as other benefits. When elevated BP is associated with obesity, efforts should be directed at reducing obesity with strategies to lower excessive calorie intake and to increase physical exercise. Correction of obesity is difficult to achieve in children as well as adults. Because of the known benefits of weight control, efforts both to prevent and to control childhood obesity should be pursued. More effective weight loss strategies for children are developing, which should facilitate more effective treatment.[34-39]

BP also is directly related to degree of physical fitness. The benefit of the increased physical activity occurs gradually over months.[30] When increases in physical activity are combined with weight loss, the reduction in BP is superior to the effect resulting from weight reduction alone.[30] Hypertension usually is not a contraindication to participation in sports and strenuous activity, particularly because exercise has a beneficial effect on BP and other risk factors. Sudden death during sporting events has not been reported in athletes with hypertension as it has in athletes with hypertrophic cardiomyopathy or cardiac arrhythmias.

Although dietary interventions to control or reduce obesity in childhood have demonstrated benefit to BP, limited data support the benefit to BP of other dietary interventions in the young. The preponderance of evidence from published clinical trials suggests that dietary sodium restriction reduces BP in adults with hypertension.[41,42] Most studies to determine whether sodium reduction lowers BP in children have been very short term.[43-45] As yet, no clear evidence supports sodium reduction as beneficial in children or adolescents with mild hypertension. However, because sodium intake is generally well in excess of needs and mild BP elevation often is associated with obesity, a moderate reduction in dietary sodium can be beneficial. Sodium restriction is also of benefit in some types of secondary hypertension such as chronic glomerulonephritis. Practical dietary considerations include an increase in fresh fruits and vegetables, elimination

of added salt to home-cooked foods in preparation and at the table, and a reduction in foods with high sodium content.

These strategies for nonpharmacologic therapy should be employed as initial treatment maneuvers for children with BP above the 90th percentile for age, gender, and height. Similarly, these nonpharmacologic methods are appropriate for children and adolescents with other risk factors for hypertension, particularly a strong family history of hypertension. Some childhood data sets[46] indicate that African American children have BP levels that are somewhat higher than those of white children, suggesting that the prevalence of high BP may be greater in African American children than white children. Recent data from California regarding Asian American children show that they also tend to have higher BP than white children.[47] With the known excess prevalence, morbidity, and mortality of essential hypertension among adult African Americans in the United States, it is advisable to be vigilant in monitoring BP and to encourage healthy diet, exercise, and weight control behaviors in African American children, especially in the presence of a family history of hypertension. This approach seems to be prudent for other groups with a higher prevalence of hypertension or individuals with a family history of high BP.

Pharmacologic Therapy

When drug therapy is used, the goal is to reduce BP to below the 95th percentile. The second task force report provided guidelines for the use of antihypertensive drugs in childhood, which continue to be endorsed.[3] These drugs and their dosing recommendations are provided in table 3, which contains the drugs recommended for acute antihypertensive therapy, and in table 4, which lists the drugs used for chronic antihypertensive therapy. Antihypertensive drug therapy should be individualized, depending on the level of BP, the degree of response, the occurrence of side effects, and the patient's medical history. Diuretics and beta-blockers have been used in treating hypertension in children and adolescents, and these medications continue to be useful. Since publication of the second task force report, a number of newer antihypertensive agents have become available and are described below.

Angiotensin-converting enzyme (ACE) inhibitors have become one of the primary agents for antihypertensive therapy not only because of their effectiveness in reducing BP but also because of their positive benefits on cardiac function, peripheral vasculature, and renal function.[48] ACE inhibitors are effective in children and can be useful in young infants and newborns.[49] Both the potency and the duration of action seem greater in this age group than in older children.[50]

A significant adverse effect of ACE inhibitors on the kidneys is severe reduction in glomerular filtration in patients with bilateral renal artery stenosis or renal artery stenosis in a solitary or transplanted kidney.[51] A more recent observation is the adverse effect of ACE inhibitors on the developing fetus. The use of ACE inhibitors during the second and third trimesters of pregnancy is associated with oligohydramnios and fetal effects of pulmonary hypoplasia, renal tubular dysplasia, and hypocalvaria as well as with hypotension and anuria after birth.[52] Because of the teratogenic risk with fetal exposure, ACE inhibitors should be used with extreme caution in adolescent girls who may be sexually active.

Calcium channel blockers constitute a class of compounds that inhibit intracellular flux of calcium. At the present time, nifedipine is the calcium channel blocker used most often for treatment of childhood hypertension. The usefulness of nifedipine in treating chronic hypertension is limited by a short duration of action. Long-acting preparations have improved the effectiveness of nifedipine, but the tablet strength makes it impractical for use in small children. Because of recent concerns about

Table 3

Antihypertensive Drug Therapy for Hypertensive Emergencies in Children

Drug	Dose
Nifedipine	0.25-0.5 mg/kg oral prn. May be repeated two times, if no response.
Sodium Nitroprusside	0.5-1 mcg/kg/min IV initially. May be increased stepwise to 8 mcg/kg/min maximum.
Labetalol	0.2-1 mg/kg/dose IV. May be increased incrementally to 1 mg/kg/dose until response achieved. 0.25-2 mg/kg/hr maintenance, either bolus or IV infusion.
Esmolol	500-600 mcg/kg IV load dose over 1-2 min then 200 mcg/kg/min. May be increased by 50-100 mcg/kg q 5-10 min to max of 1,000 mcg/kg.
Diazoxide	1-5 mg/kg/dose IV bolus up to max of 150 mg/dose.
Hydralazine	0.2-0.4 mg/kg IV prn. May be repeated two times if no response.
Minoxidil	0.1-0.2 mg/kg oral.

possible adverse effects of short-term calcium channel blockers used in adults, it has been recommended that physicians exercise caution in their use.[53,54] Presently there are no long-term data available on children using calcium channel blockers or any classes of antihypertensive agents. Most adverse effects are limited to a brief period of time after initial drug administration. The heart rate and cardiac output increase but usually return to pretreatment levels within a few weeks. Newer calcium channel blocking agents seem to have fewer side effects, although their use in children has been limited.

Benefit may be achieved with pharmacologic intervention at less severe levels of hypertension in some clinical situations. Children with confirmed chronic renal disease such as chronic glomerulonephritis should have therapy to reduce BP to below the 95th percentile to preserve renal function. Children with diabetes constitute another group of patients warranting very careful BP surveillance. There is evidence that some children with diabetes, especially those who have a strong family history of hypertension, are at greater risk for development of diabetic nephropathy.[55] Children, as well as adults, with diabetes are likely to achieve renal protective benefits from therapy to maintain BP below the 90th percentile.[56]

Extensive clinical trials have not been conducted to examine the benefits and risks of antihypertensive therapy in children and adolescents. Because of the limited data available on therapy outcomes, the guidelines for treatment of children with hypertension are conservative. Treatment of children with mild hypertension should focus on lifestyle- or health-related behavioral changes including weight reduction and increased physical activity. Children with secondary hypertension, which may or may not be curable, should have therapy directed at the underlying cause of the hypertension.

Public Health Considerations

In the general population, it is estimated that more than 70 percent of premature morbidity

Table 4

Antihypertensive Drug Therapy for Chronic Hypertension in Children

Listed in alphabetical order by drug class*

Drug	Dose (mg/kg/day) Initial	Maximum	Dosing Interval
Adrenergic-Blocking Agents			
Alpha-/Beta-Blocker			
Labetalol	1	3	q 6-12 hr
Alpha-Blocker			
Prazosin	0.05-0.1	0.5	q 6-8 hr
Beta-Adrenergic Blockers			
Atenolol	1	8	q 12-24 hr
Propranolol	1	8	q 6-12 hr
Alpha-Agonist			
Clonidine	0.05-0.1**	0.5-.6†	q 6 hr
Calcium Antagonists			
Nifedipine	0.25	3	q 4-6 hr
Nifedipine XL	0.25	3	q 12-24 hr
Converting Enzyme Inhibitors			
Captopril			
Children	1.5	6	q 8 hr
Neonates	0.03-0.15	2	q 8-24 hr
Enalapril	0.15	not established	q 12-24 hr
Diuretics			
Bumetanide	0.02-0.05	0.3	q 4-12 hr
Furosemide	1	12	q 4-12 hr
Hydrochlorothiazide	1	2-3	q 12 hr
Metolazone	0.1	3	q 12-24 hr
Spironolactone	1	3	q 6-12 hr
Triamterene	2	3	q 6-12 hr
Vasodilators			
Hydralazine	0.75	7.5	q 6 hr
Minoxidil	0.1-0.2	1	q 12 hr

*Other drugs are available in some classes, but data on dosage in children have not been published.
**Total initial dose in mg.
†Total daily dose in mg.

can be attributed to tobacco use, undertreatment of hypertension, and obesity.[57,58] From a public health perspective, health-related behaviors that reduce the risk of cardiovascular disease should be encouraged for all children and their families. In addition to monitoring BP, appropriate nutrition and exercise should be encouraged and smoking should be strongly discouraged during childhood.

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Appendix 1. Demographic Data on Height/Blood Pressure Distribution Curves of Study Population

Source	Age (year)	Gender		Ethnic Group							Persons[a] (Visits) SBP Available	Persons[b] (Visits) DBP (K5) Available	Total No. of Persons[c] (Visits)
		Boys	Girls	Black	Hispanic	White	Asian	Native American	Other	Missing			
NIH[59]	6-17	1,901	1,751	600	0	2,968	0	0	84	0	3,647 (3,647)	3,614 (3,614)	3,652 (3,652)
Pittsburgh[60]	1-5	150	137	109	0	177	0	0	0	1	287 (899)	0 (0)	287 (899)
Dallas[61,62]	13-17	5,916	5,649	5,266	1,570	4,729	0	0	0	0	11,565 (21,860)	11,565 (21,852)	11,565 (21,860)
Bogalusa[63-65]	1-17	3,752	3,611	2,483	0	4,880	0	0	0	0	7,363 (15,922)	0 (0)	7,363 (15,922)
Houston[66]	3-17	1,457	1,378	638	1,341	748	23	0	0	85	2,835 (2,835)	0 (0)	2,835 (2,835)
South Carolina[67]	4-17	3,167	3,264	3,110	0	3,321	0	0	0	0	6,431 (6,431)	6,369 (6,369)	6,431 (6,431)
Iowa[68,69]	5-17	2,100	1,993	0	0	4,093	0	0	0	0	4,093 (4,093)	0 (0)	4,093 (4,093)
Providence[10]	1-3	231	231	24	4	432	0	0	2	0	462 (906)	371 (566)	462 (906)
Minnesota[70]	9-17	9,995	9,425	3,422	556	11,320	1,678	644	1,800[d]	0	19,420 (19,420)	19,217[e] (19,217)	19,420 (19,420)
NHANES III[27]	5-17	2,489	2,609	1,793	1,851	1,334	64	10	12	34	5,027 (5,027)	4,291[e] (4,291)	5,098 (5,098)
Total	1-17	31,158	30,048	17,445	5,322	34,002	1,765	654	1,898	120	61,130 (81,040)	45,427 (55,909)	61,206 (81,116)
Percent of Total Number of People		(51)	(49)	(29)	(9)	(56)	(3)	(1)	(3)	(0)			

SBP = systolic blood pressure; DBP = diastolic blood pressure; K5 = fifth Korotkoff sound; NIH = National Institutes of Health.
[a]Number of persons (visits) at which SBP was available.
[b]Number of persons (visits) at which DBP (K5) was available.
[c]Number of persons (visits) at which either SBP or DBP (K5) was available.
[d]These children were mostly of mixed ancestry, with the predominant categories white/black or white/Hispanic.
[e]Excludes subjects with a value of 0 for the fifth Korotkoff sound.

Appendix 2. Quick-Reference Diagnostic Charts

Quick-Reference Diagnostic Charts

The quick-reference diagnostic charts are for use in the clinical setting. By following the steps listed below, clinicians can make a quick assessment for classification of blood pressure.

Classification of Blood Pressure in Children and Adolescents*

SBP and DBP < 90th percentile	Normal
SBP or DBP ≥ 90th percentile and < 95th percentile	High-Normal**
SBP or DBP ≥ 95th percentile	Hypertension**

* for age and sex

** for age and sex measured on at least three separate occasions

SBP = systolic blood pressure
DBP = diastolic blood pressure

Using the Charts

1. Use the standard height charts to determine the height percentile.
2. Measure the child's blood pressure. Record SBP and DBP.
3. Use the correct gender chart for 90th percentile of DBP.
4. Find the child's age on the right side of the chart. Follow the age line horizontally across the chart to the intersection of the line for the height percentile (vertical line).
5. Move UP or DOWN the height percentile line to the intersection of measured blood pressure.

Result on 90th Percentile Chart:

- If you move DOWN on the height percentile line, blood pressure is NORMAL. Repeat steps 3 through 5 on the chart for 90th percentile SBP.
- If you move UP on the height percentile line, you must repeat steps 3 through 5 on the chart for 95th percentile DBP.

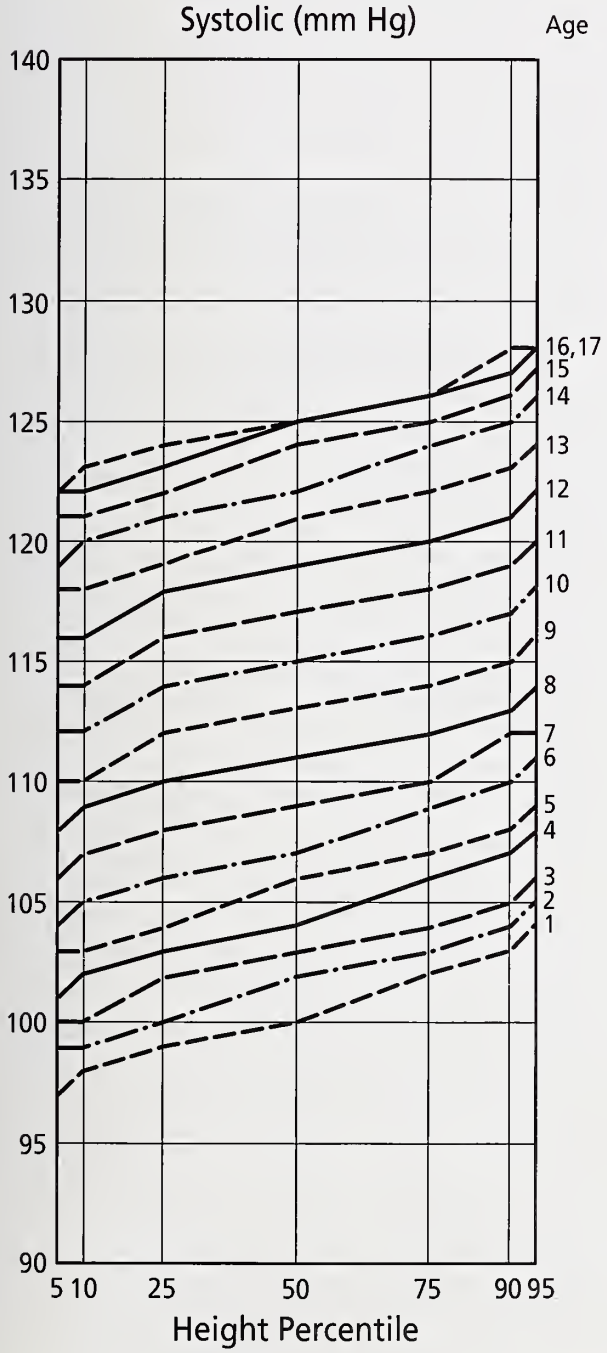
Result on 95th Percentile Chart:

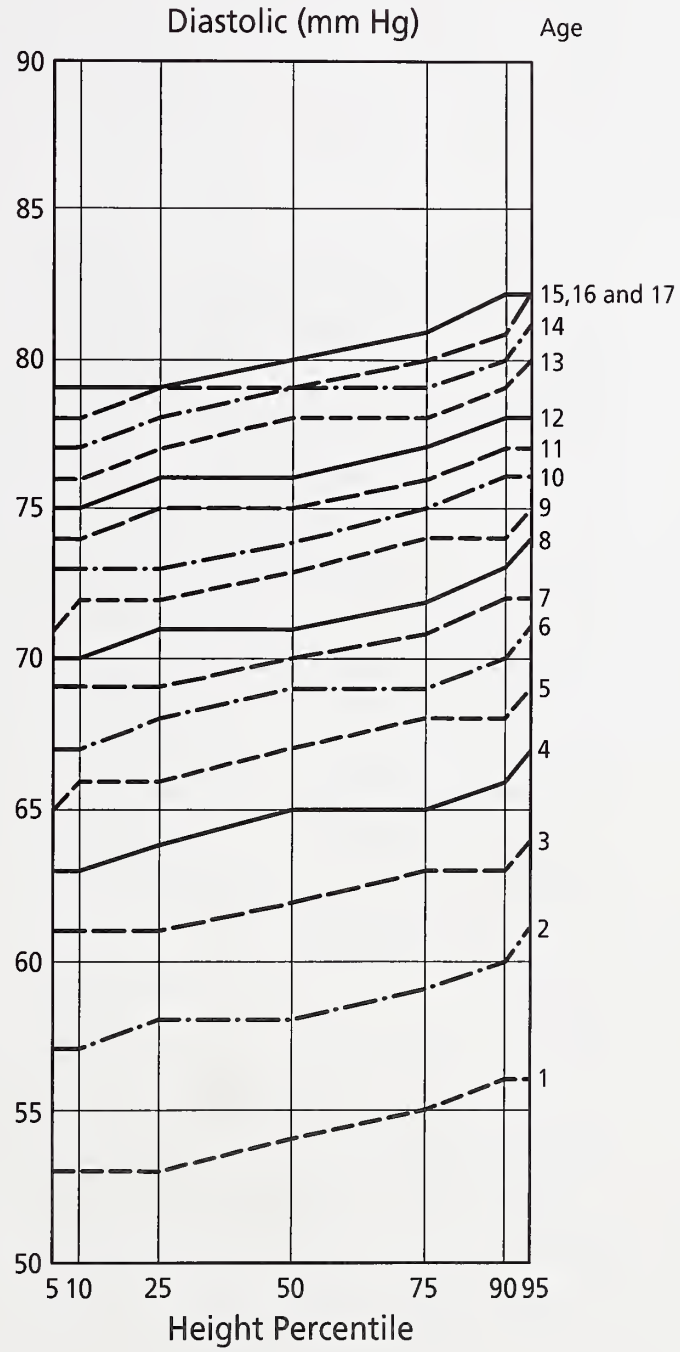
- If you move DOWN on the height percentile line, blood pressure is HIGH-NORMAL. Repeat steps 3 through 5 on the chart for 95th percentile SBP.
- If you move UP on the height percentile line, HYPERTENSION* is indicated. Repeat steps 3 through 5 on the chart for 95th percentile SBP.

Data points for the Quick-Reference Diagnostic Charts are found in tables 1 and 2.

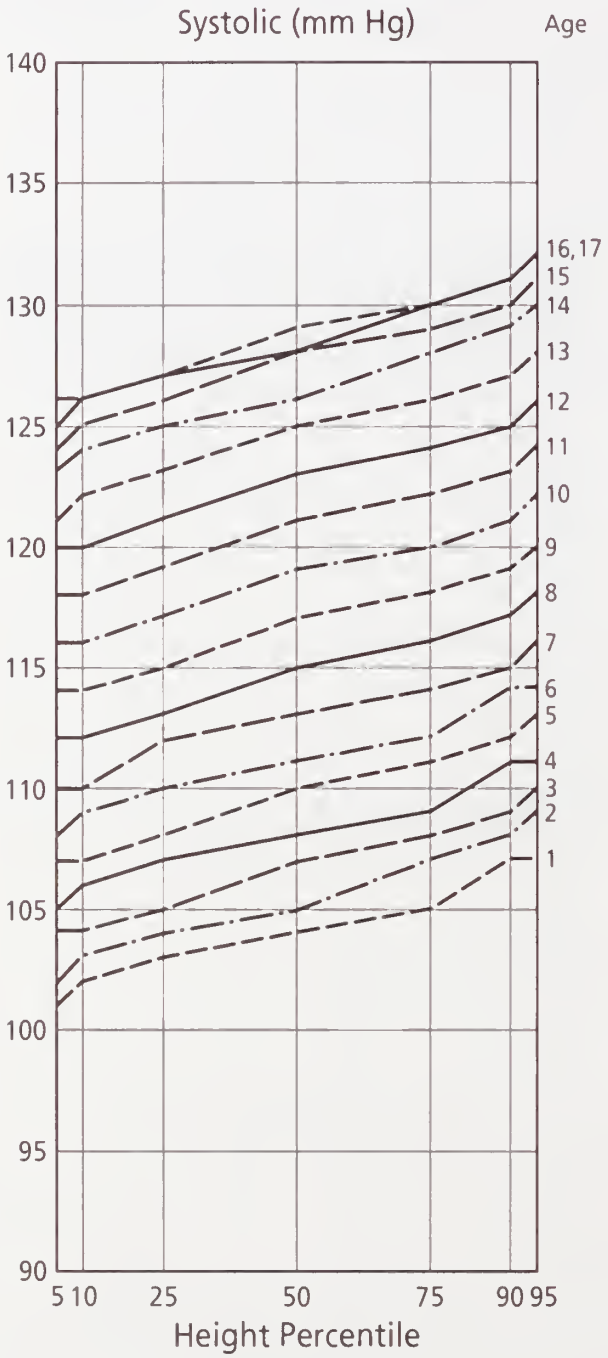
*Note that hypertension is diagnosed after three consecutive BP readings above the 95th percentile on three separate occasions.

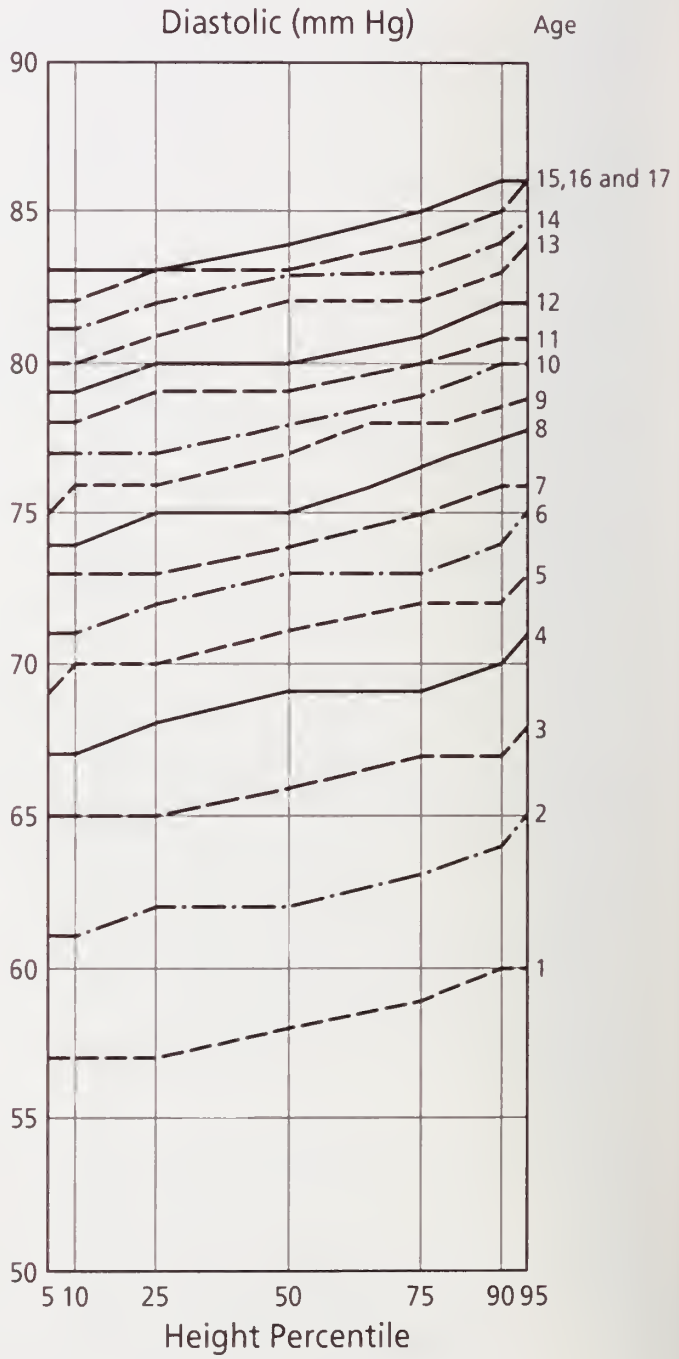
90th Percentile of Systolic and Diastolic Blood Pressure by Height and Age, Girls



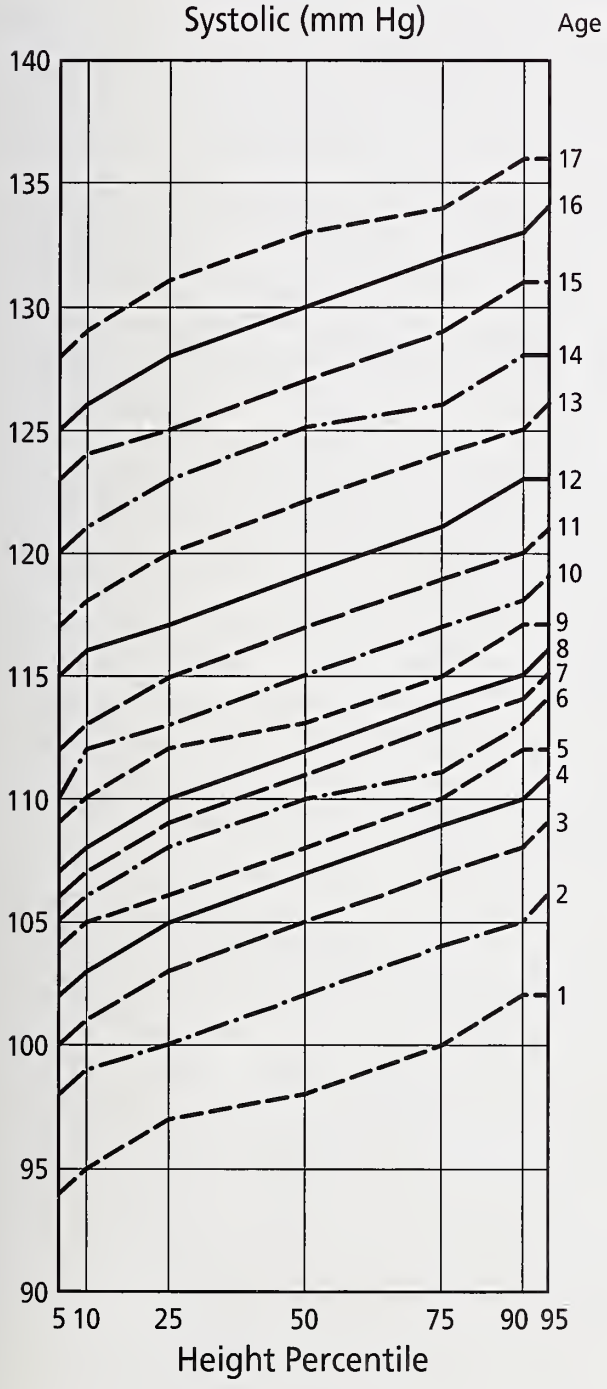


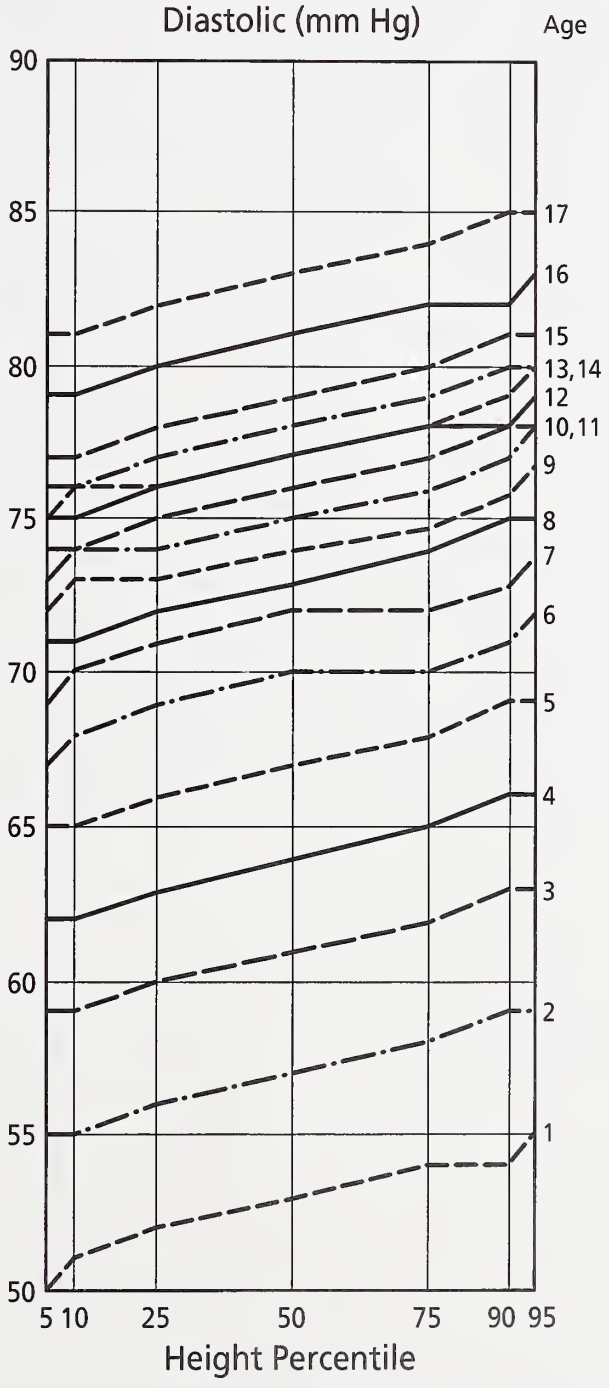
95th Percentile of Systolic and Diastolic Blood Pressure by Height and Age, Girls



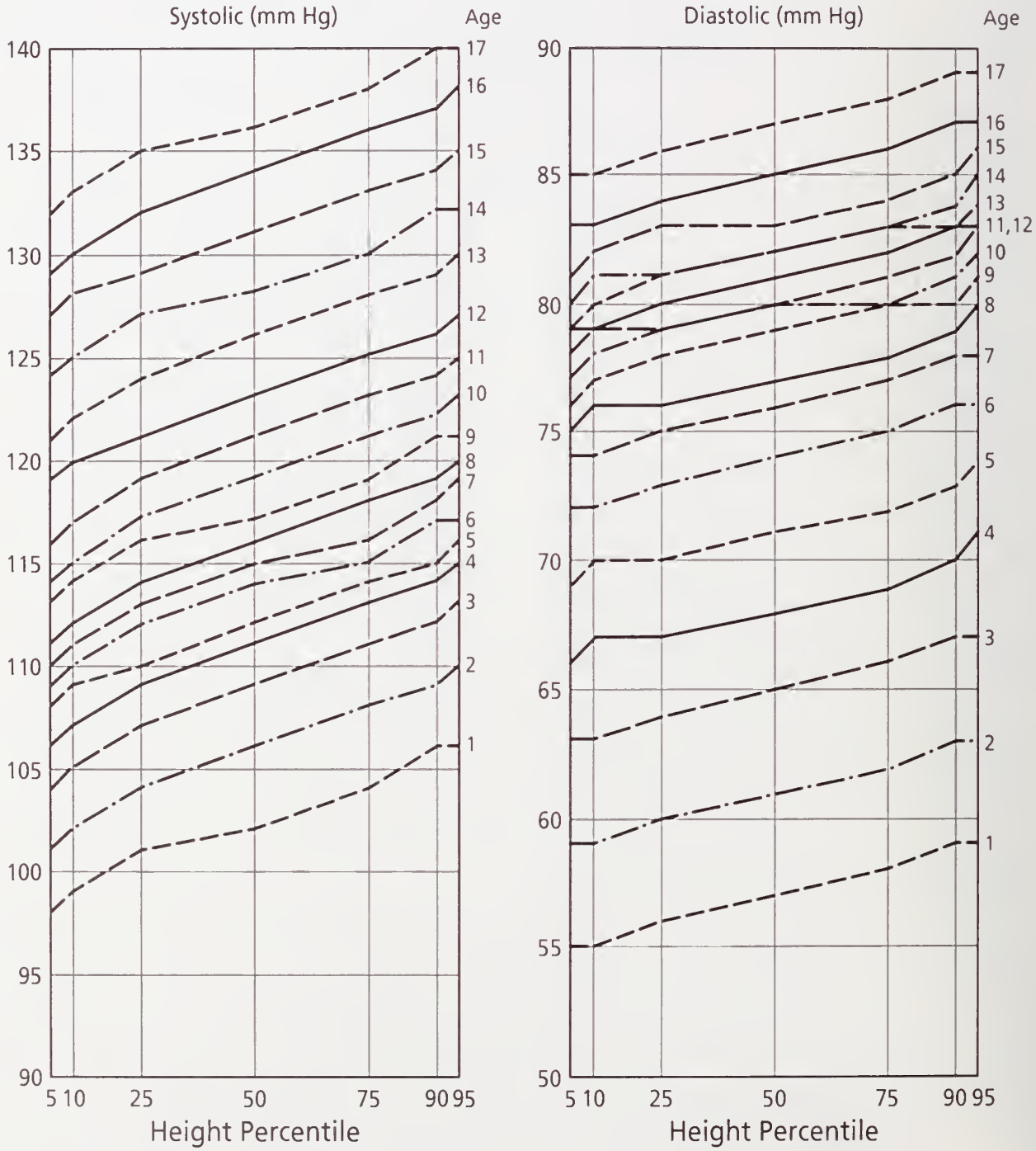


90th Percentile of Systolic and Diastolic Blood Pressure by Height and Age, Boys





95th Percentile of Systolic and Diastolic Blood Pressure by Height and Age, Boys



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U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES

Public Health Service
National Institutes of Health
National Heart, Lung, and Blood Institute

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